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(54) Title: MAP KINASE PHOSPHATASE GENE AND USES THEREOF

(57) Abstract

A novel gene is disclosed that encodes a novel dual specificity threonine-tyrosine phosphatase. It is expressed highly in the brain and may have utility in investigating signal transduction mechanisms in brain and muscle. The isolation of the gene allows one to probe for any mutations that may occur, for example extensions of the gene.

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MAP KINASE PHOSPHATASE GENE AND USES THEREOF

This invention relates to two genes encoding novel proteins that possesses threonine-tyrosine phosphatase characteristics, to the proteins themselves and methods for their recombinant production.

5 These genes are located in the cytoplasm which is a novel feature of this class of phosphatase genes.

Protein tyrosine phosphatases (PTPs) are a growing family of enzymes which play an important role, together with protein tyrosine kinases, in many cellular processes such as cell 10 division, proliferation and differentiation¹⁻³. The PTP family can be sub-divided according to structural features which determine whether they are transmembrane or cytoplasmically located. All PTPs contain a catalytic domain consisting of a highly conserved active site with the consensus sequence 15 [I/V]HCXAGXXR[S/T]G (where X represents any amino acid). The regions flanking the catalytic domain of the PTPs are diverse and consist of sequences which appear to target the PTPs to specific cellular locations.

Amongst the superfamily of tyrosine phosphatases are a sub-family 20 of dual specificity phosphatases, so-called because they can dephosphorylate substrates which are phosphorylated on both serine and threonine as well as tyrosine residues. Several of these enzymes can dephosphorylate and deactivate MAP kinase (Mitogen activated protein kinases). Genes for some of these MAP 25 kinase phosphatases are known.

The mechanism by which extracellular signals for growth and differentiation are transmitted to the nucleus to alter gene expression is the subject of much current investigation. In many cases, the transduction of these signals requires the activities 30 of key enzymes known generally as MAP kinases. MAP kinase pathways have been implicated in a large number of signal transduction pathways. For instance, the activation of MAP kinases has been observed during growth factor stimulation of DNA synthesis and during differentiation, secretion and stimulation 35 of glycogen synthesis⁴. MAP kinase has been shown to

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phosphorylate and activate effector substrates such as the transcription factors c-jun and elk-1. Known MAP kinases, and the pathways in which they are involved, have been reviewed⁵.

Map kinase is activated by phosphorylation of threonine and tyrosine by a dual specificity kinase, "MAP kinase kinase". This kinase is in turn activated by phosphorylation by "MAP kinase kinase kinase", one form of which is the proto-oncogene c-raf. The activation of c-raf is not fully understood at present but apparently there is a requirement for an interaction with GTP-bound p21 ras protein⁶.

The full picture of how MAP kinase pathways are switched off is not yet clear. Down-regulation of MAP kinase activity by dephosphorylation is likely to be of key importance. The human gene CL100⁷ and its murine homologue 3CH134⁸ were originally discovered as genes whose transcription was stimulated by growth factors, oxidative stress and heat shock. Subsequently, they were shown to encode polypeptides that have both serine/threonine and tyrosine phosphatase activity^{9,10} on MAP kinase. This removal of phosphate from both threonine and tyrosine on MAP kinase is unusual. When expressed in vitro⁶ the CL100¹⁰ gene product has been shown to be very specific for MAP kinase and leads to its inactivation. Co-expression of the murine gene 3CH134 and the erk2 MAP kinase isoform in mammalian cells leads to the dephosphorylation and inactivation of the MAP kinase¹¹. Furthermore, it has been shown recently that this phosphatase gene can also block cellular DNA synthesis induced by an activated version of the ras oncogene in rat embryo fibroblasts¹².

For present purposes, the terms "Mitogen-activated protein-kinase", "MAP kinase" and "MAPK" all apply to protein kinases that are activated by dual phosphorylation on threonine and tyrosine residues. This may be in response to a wide array of stimuli. Different MAP kinases are activated in response to different extracellular stimuli, including (depending on the MAPK) stress, osmotic stress, mating pheromone (in yeast), growth factors, TNF, IL-1 and LPS. Map kinases include SMK1, HOG1,

MPK1, FUS3/KSS1, spk1, ERK1/ERK2, JNK/SAPK and p38. "MAP kinase phosphatase" activity or function is the ability to dephosphorylate one, or sometimes both, of the threonine and tyrosine residues on a MAP kinase, which residues are 5 phosphorylated on activation of the MAP kinase. Thus, MAP kinase phosphatases are capable of hydrolysing either, or both, phosphothreonine and phosphotyrosine residues on a MAP kinase.

Martell et al, (October 1995). J. Neurochem. 65: 1823, describe the cloning of a protein tyrosine kinase abundant in brain. 10 Theodosiou et al (1996) Hum. Molec. Genet. 5: 675 report the cloning of the murine M3/6 cDNA which is also described herein.

The present invention has arisen from the characterisation of a region in cosmids corresponding to yeast artificial chromosomes²² during which a series of cDNA clones were identified. One of 15 these, designated M3/6, was isolated from a mouse adult brain cDNA library. The cDNA of the invention shows homology to a family of phosphatases and appears to define a new subfamily of phosphatases. Significantly, this cDNA contains a translated complex repeat at its 3' end which may be polymorphic.

20 We have thus surprisingly found two genes that encode new proteins that appear to be a new members of the dual-specificity phosphatase family. We have called the new murine protein M3/6. A cDNA sequence of murine M3/6 is presented as Figure 1. Another cDNA sequence of the gene is presented as Figure 2, together with 25 a translation of the open reading frame. All amino acid sequences represented herein are represented in the conventional N- to C- terminal direction, in the standard one letter code, unless this is specified to the contrary.

The partial cDNA sequence of the human homologue, Hb5, is shown 30 in Figure 3. The cDNA sequence has been cloned. It shows about 81% identity at the nucleotide level to the murine sequence. Figure 4 shows an alignment between the open reading frame of the murine (top sequence) and human genes. The murine gene contains a trinucleotide repeat region which is not present in the human

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hVH-5 gene. Excluding this region, the two protein sequences are about 90% homologous (where this term means amino acid identity).

The invention provides a protein of murine, human or other mammalian origin based on the cDNA information provided herein.

- 5 As shown in Example 2, mRNA can be detected in the eye, brain, lung and other tissues of mice and human fetal liver, kidney, lung and brain tissue using the cDNA of the present invention, the cloning of which is described in Example 1. Translation of the cDNA obtained from Example 1 in a coupled reticulocyte assay
- 10 indicated that it encodes a polypeptide of approximate molecular weight of 80 kD.

Thus the invention provides a murine phosphatase designated M3/6 or a human or other mammalian homologue thereof which phosphatase is characterized by the following features:

- 15 (a) it is encoded by a cDNA sequence obtainable from a mammalian brain cDNA library, said DNA sequence being selectively detectable with a murine DNA sequence as shown in Figure 1 or one or more of the human DNA sequences shown in Figure 3; and
- 20 (b) it comprises a phosphatase catalytic domain of the sequence VHCXAGXXRSX, where X is any amino acid.

Preferably the catalytic domain sequence is VHCLAGISRSA.

The protein desirably has the additional feature of either:

- (c') tyrosine phosphatase activity, or:
- 25 (c") threonine phosphatase activity.

Preferably it has both activities.

The protein preferably has one or more of the additional features:

- 30 (d) it has a sequence of 299 amino acids at its N-terminus which are substantially as the M3/6 sequence shown in Figure 5;
- (e) it has a cytoplasmic location in at least some cell types;
- (f) it is encoded by an mRNA of approximately 5kb; and

(g) it comprises a C-terminal region rich in serine.

In a preferred aspect, the phosphatase is M3/6 of murine origin, in which case at least one of features (c') and (c''), together with all of features (d) to (g) may be present. However the 5 phosphatase may also be of human origin. In this case at least one of features (c') and (c'') plus feature (d) may be present.

The term "selectively detectable" means that the cDNA used as a probe is used under conditions where a target cDNA of the invention is found to hybridize to the probe at a level 10 significantly above background. The background hybridization may occur because of other cDNAs present in the brain cDNA library. In this event background implies a level of signal generated by interaction between the probe and a non-specific cDNA member of the library which is less than 10 fold, preferably less than 100 15 fold as intense as the specific interaction observed with the target cDNA. The intensity of interaction may be measured, for example, by radiolabelling the probe, e.g. with ^{32}P .

Suitable conditions may be found by reference to the Examples. The cDNA of Figure 1 can detect both murine and human DNA at 20 0.1xSSC, 0.1% SDS at 55°C (where 1xSSC is 0.15M sodium citrate, 0.15 M sodium chloride at pH7.5).

Tyrosine and threonine phosphatase activity assays are generally well known in the art and any suitable assay may be used. Reference may be made for example to Fischer et al, 1991, Science 25 253; 401-406 or Zeng and Guan, 1993, *J. Biol. Chem.*, 268;16116-16119.

Preferably all the proteins of the invention will have dual specificity phosphatase activity, namely they are capable of dephosphorylation at both Ser/Thr and Tyr residues. However, it 30 should be borne in mind that phosphatase activity for the M3/6 protein has not yet been demonstrated, although homology with other sequences (see Example 1) strongly suggest this. It is therefore possible that this and the other polypeptides of the

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invention may in fact have alternative and/or additional activities, functions or roles.

The sequence of 299 amino acids at the N-terminus of proteins of the invention will be at least 80%, preferably at least 90%, more 5 preferably at least 95% and most preferably at least 97.5% homologous to the M3/6 sequence of Figure 5.

The cytoplasmic location of the protein of the invention may be determined in accordance with methods described in the accompanying examples. Cells which may be examined to determine 10 cellular localization are preferably neuronal cells such as PC12 cells in at least some cell types.

The cDNA is encoded by an mRNA of approximately 5kb. It will be appreciated that determination of mRNA size is often (as is the present case) established by northern blotting techniques 15 and thus is limited in accuracy by the limitations of this technique. In addition there will be some heterogeneity of the size of the polyA tail of mRNA molecules. An approximate size of 5kb will be understood by those of skill in the art to have a tolerance of at least ± 0.5 kb. Nonetheless, approximate mRNA 20 size is still a useful characteristic for determining the identity of a protein.

We have found that the C-terminal region of the murine protein of encoded by the cDNA sequences of the invention are rich in serine, and also glycine. The present invention can thus be 25 broadly thought of as relating to a phosphatase, such as a dual specificity phosphatase, that possesses at least one region of amino acid repeats at least in the murine variant of such a protein. Such repeats will be a contiguous and continuous repeat of the same amino acid. The repeat, or each repeat, may be of 30 glycine (G) and/or serine (S) residues. Each repeat may be at least four or five, such as ten, amino acids in length. The repeat may be no longer than 20, such as 30 or 40, amino acids.

5 The presence of at least one stretch of 19 contiguous serine residues in the C-terminal region (i.e. within 150 or 200 amino acids) is indicative of at least the murine form of the protein of the present invention. This C-terminal region may also comprise a stretch of at least 17 contiguous glycine residues.

In addition to M3/6 and mammalian homologues thereof the present invention also contemplates:

10 (a) an allelic variant of such proteins;
(b) a protein at least 80% homologous to such proteins;
(c) a fragment of any one of such proteins (or (a) or (b) having phosphatase activity and being of at least 15 amino acids long; or
(d) a fusion protein comprising such proteins (or any one of (a) to (c)).

15 15 All proteins and polypeptides within this definition are referred to below as proteins or polypeptide(s) according to the invention.

20 A protein or polypeptide of the invention will preferably be in substantially isolated form, i.e in a form in which it is free of other polypeptides with which it may be associated in its natural environment (eg the body). It will be understood that the polypeptide may be mixed with carriers or diluents which will not interfere with the intended purpose of the polypeptide and yet still be regarded as substantially isolated.

25 25 The polypeptide of the invention may also be in a substantially purified form, in which case it will generally comprise the polypeptide in a preparation in which more than 90%, eg. 95%, 98% or 99% of the polypeptide in the preparation is a polypeptide of the invention.

30 30 Mutant proteins or polypeptides are also contemplated in accordance with the invention. These will possess one or more mutations each of which is one or more additions, deletions, or substitutions of amino acid residues. Preferably the mutations will not affect, or substantially affect, the structure and/or

function and/or properties of the polypeptide. Thus, mutants may suitably possess phosphatase activity, preferably dual specificity phosphatase activity. Mutants can either be naturally occurring (that is to say, purified or isolated from a natural source) or synthetic (for example, by performing site-directed mutagenesis on the encoding DNA). It will thus be apparent that polypeptides of the invention can be either naturally occurring or, preferably, recombinant (that is to say prepared using genetic engineering techniques).

5 10 An allelic variant will be a variant which will occur naturally in a human or murine animal and which will dephosphorylate in a substantially similar manner to the proteins of the invention.

Similarly, a species homologue of the M3/6 protein will be the equivalent protein which occurs naturally in another species, eg. 15 other than mouse or human, and which performs the equivalent or similar function in that species. Within any one species, a homologue may exist as several allelic variants, and these will all be considered homologues of the protein. Allelic variants and species homologues can be obtained by following the 20 procedures described herein for the production of a protein of Example 3 and performing such procedures on a suitable cell source, eg from human or a rodent, carrying an allelic variant or another species. Since the protein may be evolutionarily conserved it will also be possible to use a polynucleotide of the 25 invention to probe libraries made from human, rodent or other cells in order to obtain clones encoding the allelic or species variants. The clones can be manipulated by conventional techniques to identify a polypeptide of the invention which can then be produced by recombinant or synthetic techniques known per 30 se. Preferred species homologues include mammalian or amphibian species homologues.

A protein at least 80% homologous to the M3/6 protein is included in the invention, as are proteins at least 90% and more preferably at least 95% homologous to this protein. This will 35 generally be over a region of at least 20, preferably at least 30, for instance at least 40, 60 or 100 or more contiguous amino

acids. Methods of measuring protein homology are well known in the art and it will be understood by those of skill in the art that in the present context. Homology is usually calculated on the basis of amino acid identity (sometimes referred to as "hard homology").

Generally, polypeptide fragments of a M3/6 protein or its allelic variants or species homologues thereof capable of exhibiting phosphatase activity will be at least 10, preferably at least 15, for example at least 20, 25, 30, 40, 50 or 60 or 100 amino acids 10 in length.

It will be possible to determine whether the proteins or polypeptides of the invention exhibit phosphatase activity using standard routine techniques, a suitable test being given later in this specification in Example 6. Alternatively one may 15 examine the sequence of the protein to see if it possesses the characteristic phosphatase catalytic domain, namely: (I/V)HCXAGXXR(S/T)G, wherein X represents any amino acid. In the M3/6 polypeptide of the invention this potential catalytic domain is found at 244-254 of the protein encoded by Figure 2, except 20 in both cases the C-terminal G is replaced by A.

Preferred fragments of proteins of the invention include those which exhibit phosphatase activity and/or possess the above catalytic domain sequences. The Examples presented herein describe a number of methods to analyze the function of the 25 protein and these may be adapted to assess whether or not a polypeptide possesses certain activities.

In Figure 5 the conceptual translation of half of (the 5' end of) the M3/6 coding sequence is aligned and compared with the human CL100 MAP kinase phosphatase protein sequence. A high degree of 30 homology between the sequences can be seen, further indicating phosphatase activity for the M3/6 protein.

A polypeptide of the invention may be labelled with a revealing or detectable label. The (revealing) label may be any suitable label which allows the polypeptide to be detected. Suitable

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labels include radioisotopes, e.g. ^{125}I , enzymes, antibodies and linkers such as biotin. Labelled polypeptides of the invention may be used in diagnostic procedures such as immunoassays in order to determine the amount of phosphatases in a sample.

5 A polypeptide or labelled polypeptide according to the invention may also be fixed to a solid phase, for example the wall of an immunoassay dish.

In a second aspect of the invention, there is provided a polynucleotide which comprises:

10 (a) a sequence encoding a protein or polypeptide of the invention as defined above or the complement of said sequence;
(b) a sequence of nucleotides shown in Figure 1 or Figure 2;
15 (c) a sequence capable of selectively hybridising to a sequence in either (a) or (b); or
(d) a fragment of any of the sequences in (a) to (c).

The polynucleotide of the present invention is suitably in substantially isolated or purified form.

20 Polynucleotides of the invention include the DNA sequence of Figure 1 and fragments thereof capable of selectively hybridizing to the sequence of Figure 1. Polynucleotides of the invention also include polynucleotides comprising human cDNA characterized by the presence of one or more of the sequences shown in Figure 25 3.

The present invention in one embodiment provides a nucleic acid sequence comprising the nucleotide sequence according to Figure 1. This (murine) protein has an ATG initiation codon as shown in Figures 1 and 2. Amino acid residues encoded by the protein of Figure 2 - which are also encoded by the sequence of Figure 1 - show high homology to the cdc25 PTP of yeast²⁸ at residues 30 29-49 and 117-136. The sequence shows high homology to several PTPs in the public database EMBLGENBANK. This M3/6 gene is

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murine; parts of the gene encoding for the human homologue (Hb5) are shown in Figure 3.

The gene that encodes the protein we have called M3/6 (which appears to be a tyrosine phosphatase), contains a complex triplet 5 distal to the catalytic domain which is translated into protein. This domain comprises a run of four serine residues which is followed by a run comprising 17 glycine residues which in turn is followed by a further run comprising 23 serine residues which is interrupted near the N-terminal section by a single 10 asparagine.

It is thought that this repeat might cause instability of this domain if it expands. Any expansion of this triplet repeat may disrupt the normal activity of the protein in the cell and lead to a disease phenotype in a way similar to other neurological 15 disorders. This protein is highly expressed in the brain with much lower levels in liver and spleen tissues.

It will be appreciated that in polynucleotides of the invention, which encompass nucleic acid encoding a polypeptides of the invention, triplet repeats of the codons encoding the repeated 20 amino acid residues may be present. Such codons may encode for either glycine and/or serine residues. Such triplet repeats may be at least 15, such as at least 30, bases in length, generally up to a maximum of 60 nucleotides.

If glycine residues are repeated, then triplet repeats of $(GGC)_n$ 25 or $(GGT)_n$ (which are 2 of the 4 codons encoding Gly) can be present. Here the number n is an integer, suitably from 4, 5 or 10 up to 20. For serine, repeats of $(AGT)_m$ or $(AGC)_m$ (this residue has a degeneracy of 6) may exist. The variable m is also an integer, such as from 4 to 20.

30 The polynucleotide of the invention may also comprise RNA. It may also be a polynucleotide which includes within it synthetic or modified nucleotides. A number of different types of modification to oligonucleotides are known in the art. These include methylphosphonate and phosphorothionate backbones,

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addition of acridine or polylysine chains at the 3' and/or 5' ends of the molecule. For the purposes of the present invention, it is to be understood that the oligonucleotides described herein may be modified by any method available in the art. Such 5 modifications may be carried out in order to enhance the *in vivo* activity or lifespan of oligonucleotides of the invention used in methods of therapy.

A polynucleotide capable of selectively hybridizing to the DNA of Figure 1, 2 or 3 will be generally at least 70%, preferably 10 at least 80 or 90% and optimally at least 95% homologous to the DNA of Figure 1, 2 or 3 over a region of at least 20, preferably at least 30, for instance at least 40, 60 or 100 or more contiguous nucleotides. These polynucleotides are also within the invention.

15 A polynucleotide of the invention will be in substantially isolated form if it is in a form in which it is free of other polynucleotides with which it may be associated in its natural environment (usually the body). It will be understood that the polynucleotide may be mixed with carriers or diluents which will 20 not interfere with the intended purpose of the polynucleotide and it may still be regarded as substantially isolated.

A polynucleotide according to the invention may be used to produce a primer, e.g. a PCR primer, or a probe e.g. labelled with a revealing or detectable label by conventional means using 25 radioactive or non-radioactive labels, or the polynucleotide may be cloned into a vector. Such primers, probes and other fragments of the DNA of Figure 1, 2 or 3 will be at least 15, preferably at least 20, for example at least 25, 30 or 40 nucleotides in length, and are also encompassed within the 30 invention.

Polynucleotides, such as a DNA polynucleotides according to the invention may be produced recombinantly, synthetically, or by any means available to those of skill in the art. It may be also cloned by reference to the techniques disclosed herein.

The invention includes a double stranded polynucleotide comprising a polynucleotide according to the invention and its complement.

A third aspect of the invention relates to an (eg. expression) 5 vector suitable for the replication and expression of a polynucleotide, in particular a DNA or RNA polynucleotide, according to the invention. The vectors may be, for example, plasmid, virus or phage vectors provided with an origin of 10 replication, optionally a promoter for the expression of the polynucleotide and optionally a regulator of the promoter. The vector may contain one or more selectable marker genes, for example an ampicillin resistance gene in the case of a bacterial plasmid or a neomycin resistance gene for a mammalian vector. 15 The vector may be used *in vitro*, for example for the production of RNA or used to transfect or transform a host cell. The vector may also be adapted to be used *in vivo*, for example in a method of gene therapy.

Vectors of the third aspect are preferably recombinant replicable vectors. The vector may thus be used to replicate the DNA. 20 Preferably, the DNA in the vector is operably linked to a control sequence which is capable of providing for the expression of the coding sequence by a host cell. The term "operably linked" refers to a juxtaposition wherein the components described are 25 in a relationship permitting them to function in their intended manner. A control sequence "operably linked" to a coding sequence is ligated in such a way that expression of the coding sequence is achieved under condition compatible with the control sequences. Such vectors may be transformed or transfected into 30 a suitable host cell to provide for expression of a polypeptide of the invention.

A fourth aspect of the invention thus relates to host cells transformed or transfected with the vectors of the third aspect. This may allow for the replication and expression of a polynucleotide according to the invention, such as the sequence 35 of Figure 1, or the open reading frame thereof. The cells will

be chosen to be compatible with the vector and may for example be bacterial, yeast, insect or mammalian.

A polynucleotide according to the invention may also be inserted into the vectors described above in an antisense orientation in

5 order to provide for the production of antisense RNA. Antisense RNA or other antisense polynucleotides may also be produced by synthetic means. Such antisense polynucleotides may be used in a method of controlling the levels of the M3/6 phosphatase protein in a cell and/or tissue.

10 Thus, in a fifth aspect the invention provides a process for preparing a polypeptide according to the invention which comprises cultivating a host cell (eg. of the fourth aspect) transformed or transfected with an (expression) vector of the third aspect under conditions providing for expression (by the vector) of a coding sequence encoding the polypeptide, and

15 recovering the expressed polypeptide.

The invention in a sixth aspect also provides (monoclonal or polyclonal) antibodies specific for a polypeptide of the invention. Antibodies of the invention include fragments thereof

20 as well as mutants that retain the antibody's binding activity.

The invention further provides a process for the production of monoclonal or polyclonal antibodies to a polypeptide of the invention. Monoclonal antibodies may be prepared by conventional hybridoma technology using a polypeptide of the invention as an

25 immunogen. Polyclonal antibodies may also be prepared by conventional means which comprise inoculating a host animal, for example a rat or a rabbit, with a polypeptide of the invention and recovering immune serum.

In view of the presence of sequences in proteins of the present

30 invention which are substantially homologous to sequences present in other proteins, particularly phosphatases, the antibodies will preferably be selective for the M3/6 protein and its mammalian homologues, i.e they will not recognize epitopes found on other phosphatases, particularly tyrosine/threonine phosphatases.

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Fragments of monoclonal antibodies which retain antigen binding activity, such Fv, F(ab') and F(ab₂)' fragments are included in this aspect of the invention. In addition, monoclonal antibodies according to the invention may be analyzed (eg. by DNA sequence

5 analysis of the genes expressing such antibodies) and humanized antibody with complementarity determining regions of an antibody according to the invention may be made, for example in accordance with the methods disclosed in EP-A-0239400 (Winter).

The present invention further provides compositions comprising

10 the antibody or fragment thereof of the invention together with a carrier or diluent. Polypeptides, polynucleotides, vectors and hosts of the invention can be present in compositions together with a carrier or diluent. These compositions include pharmaceutical compositions where the carrier or diluent will be

15 pharmaceutically acceptable.

Pharmaceutically acceptable carriers or diluents include those used in formulations suitable for oral, rectal, nasal, topical (including buccal and sublingual), vaginal or parenteral (including subcutaneous, intramuscular, intravenous, intradermal,

20 intrathecal and epidural) administration. The formulations may conveniently be presented in unit dosage form and may be prepared by any of the methods well known in the art of pharmacy. Such methods include the step of bringing into association the active ingredient with the carrier which constitutes one or more

25 accessory ingredients. In general the formulations are prepared by uniformly and intimately bringing into association the active ingredient with liquid carriers or finely divided solid carriers or both, and then, if necessary, shaping the product.

For example, formulations suitable for parenteral administration

30 include aqueous and non-aqueous sterile injection solutions which may contain anti-oxidants, buffers, bacteriostatis and solutes which render the formulation isotonic with the blood of the intended recipient; and aqueous and non-aqueous sterile suspensions which may include suspending agents and thickening

35 agents, and liposomes or other microparticulate systems which are

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designed to target the polypeptide to blood components or one or more organs.

Polynucleotides, vectors, host cells and polypeptides, according to the invention, and antibodies or fragments thereof and 5 compositions comprising them may be used for the treatment, regulation or diagnosis of conditions, in a mammal including man. Such conditions include those associated with aberrant (eg due to a mutation in the gene sequence) expression of one or more of the M3/6 or Hb5 proteins or related family members. Treatment 10 or regulation of conditions with the above-mentioned moieties, especially polypeptides, antibodies, fragments thereof and compositions etc. will usually involve administering to a recipient in need of such treatment an effective amount of a polypeptide, antibody, fragment thereof or composition, as 15 appropriate.

The present invention further provides a method of performing an immunoassay for detecting the presence or absence of a polypeptide of the invention in a sample, the method comprising:

- (a) providing an antibody according to the invention;
- 20 (b) incubating the sample with the antibody under conditions that allow for the formation of an antibody-antigen complex; and
- (c) detecting, if present, the antibody-antigen complex.

25 Vectors carrying a polynucleotide according to the invention or a nucleic acid according to the invention may be used in a method of gene therapy. Methods of gene therapy include delivering to a cell in a patient in need of treatment an effective amount of a vector capable of expressing in the cell a polypeptide of the invention.

30 Such vectors are preferably viral vectors. The viral vector may be any suitable vector available in the art for targeting particular cells. For example, Huber et al (Proc. Natl. Acad. Sci. USA (1991) 88, 8039) report the use of amphotrophic retroviruses for the transformation of hepatoma, breast, colon

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or skin cells. Culver et al (Science (1992) 256; 1550-1552) also describe the use of retroviral vectors in virus-directed enzyme prodrug therapy, as do Ram et al (Cancer Research (1993) 53; 83-88). Englehardt et al (Nature Genetics (1993) 4; 27-34 describe 5 the use of adenovirus based vectors in the delivery of the cystic fibrosis transmembrane conductance product (CFTR) into cells.

The invention also contemplates (diagnostic) assays. This might involve conducting an assay to find a dephosphorylation modulator, such as an inhibitor of dephosphorylation, or in other 10 words an inhibitor of the polypeptides of the invention. It is thought that certain proteins (such as MAP kinases) are deactivated by dephosphorylation. Therefore, an inhibitor of dephosphorylation is likely to inhibit deactivation.

Thus, one assay contemplated by the invention is to identify a 15 modulator of the phosphatase polypeptides of the invention. The assay may comprise contacting a potential chemotherapeutic agent with a protein, such as an enzyme, that will usually be dephosphorylated by a phosphatase polypeptide of the invention, and observing the phosphorylation state of the enzyme. The 20 enzyme may be present in an extract from a cell which contains that enzyme. Enzymes contemplated include kinases, such as MAP kinases.

The polynucleotides of the invention may thus find use as probes 25 in diagnosis, in particular diagnosis or prognosis of tumours associated with deletions in the chromosome 11, particularly 11p15 and more especially in 11p15.5. Such tumours include brain or lung tumours.

These probes may be used to detect polynucleotides of the invention, which detection may indicate that an individual has, 30 or possesses predisposition to, a disease or disorder such as a neurodegenerative or proliferative disorder. Suitable probe detection and hybridisation techniques are well known in the art.

The M3/6 and Hb5 genes of the invention may be responsible, if 35 mutated, for various neurodegenerative or proliferative diseases. Several repeat regions have been identified in M3/6, namely

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triplet repeats that encode glycine (one repeat of 17 amino acids) and serine (3 repeats of 4, 5 and 19 amino acids respectively). The present invention thus relates to the diagnosis of susceptibility to disorders such as 5 neurodegenerative or proliferative disorders by detecting the presence or absence of these repeat regions. By use of the unmutated gene or protein individuals may be treated that possess a neurodegenerative disease or disorder.

10 The probes of the present invention are hybridisable to polynucleotides of the invention suitably under low stringency conditions. However, it is preferred that hybridisation take place under high stringency conditions. By low stringency conditions one envisages 3X SSC (0.5M sodium chloride, pH7.5) at room temperature. High stringency conditions that are envisaged 15 are 0.1X SSC (0.1M sodium chloride, pH7.5) at 65°C.

It will be apparent that probes contemplated may be capable of hybridising to the region of triplet repeats. In the M3/6 gene, this is encompassed by nucleotides 1756 to 1875 of the sequence shown in Figure 1. Such probes will be at least 15, preferably 20 at least 20, for example 25, 30 or 40, nucleotides in length.

The invention can thus provide a method of screening for susceptibility to a disease or disorder such as a neurodegenerative or proliferative disorder, which method comprises detecting, and possibly analysing, the triplet repeat 25 region (present in polynucleotides of the invention) of an individual.

The method may involve the polymerase chain reaction (PCR). It is preferred that such methods will not require the use or radiolabelled nucleotides. Detection of a normal triplet repeat, 30 such as is present in the M3/6 protein, may indicate than an individual's susceptibility to the neurodegenerative disorder or disease is low.

The method may also extend to diagnosing susceptibility to a disorder or disease such as a neurodegenerative or proliferative

disorder which method comprises detecting, if present, an amplification in a GGC, GGT, AGT or AGC repeat in a region of the human or animal genome that corresponds to the location of a polynucleotide of the present invention.

- 5 An amplification in the polynucleotide repeat may be determined by removing a sample or genomic DNA from the patient, carrying out a PCR with primers upstream and downstream of the repeat region, and determining the amount of nucleic acid produced. PCR generally does not occur to a substantial extend across genomic
- 10 DNA comprising a repeat of 30 repeats or more. Substantial amounts of nucleic acid are only produced by PCR carried out on a DNA fragment in which there is little or no amplification of the nucleotide repeat, i.e. less than 30 repeats.

In the accompanying drawings, which are provided to illustrate

15 the present invention:

- Figure 1 gives a cDNA sequence of the M3/6 gene;
- Figure 2 gives another cDNA sequence of the M3/6 gene and the open reading frame thereof;
- 20 Figure 3 shows portions of the cDNA sequence encoding the Hb5 human homologue;
- Figure 4 shows an alignment between the open reading frame of the murine (top sequence) M3/6 and human Hb5 genes. The latter is as disclosed in Martell et al, *ibid*;
- 25 Figure 5 gives the N-terminal sequence of the M3/6 protein, and aligns it with the CL100 phosphatase, from which two proteins a consensus sequence is derived; and
- Figure 6 is a graphical representation of the hVH-5 gene structure.

The following Examples describe the isolation and

30 characterization of the novel protein and DNA of the invention from murine and human sources. However, other e.g. mammalian sources are within the scope of the present invention and other mammalian homologues of the protein may be isolated in an analogous manner. The Examples are presented here by way of

35 illustration and are not to be construed as limiting on the invention.

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EXAMPLE 1 - Sequence data

A novel nucleic acid sequence (murine M3/6) is presented which encodes a putative dual specificity threonine-tyrosine phosphatase which may be used in the characterisation of 5 signalling mechanisms in brain and muscle. The presence of a complex trinucleotide repeat, located at the 3'end of this sequence and which is translated, makes this phosphatase gene a candidate for a human disease caused by repeat expansion or mutation. Fragments of the human gene homologue (Hb5) are also 10 presented.

Isolation of M3/6.

A human fragment from a yeast artificial chromosome (YAC) was isolated. Such YACs contain well over 50kb and to produce smaller, manageable sized segments for analysis were subcloned 15 into cosmids of 45kb or less each. A series of cDNA clones were identified from these cosmids.

M3/6 was isolated from a mouse brain cDNA library constructed from oligo dT and random primed cDNA (Blake, D.J., Nawrotzki, R. and Davies, K. E. Isoform diversity of the murine 87K 20 postsynaptic protein; submitted), cloned into the EcoRI site of the vector pcDNAII.

pcDNAII is a 2.9 kb plasmid vector from Invitrogen and contains the Ampicillin resistance gene. The M3/6 cDNA was isolated from the host cells XL1-Blue, by standard alkaline lysis method of 25 preparing plasmid DNA. The 2.5 kb insert containing the entire M3/6 cDNA was released from the vector by digestion with the restriction enzyme EcoRI. The insert was separated from the vector by gel electrophoresis on 1% agarose and purified using spin columns. The purified insert was radiolabelled using 30 Amersham megaprime labelling kit. M3/6/4e is a deletion derivative of M3/6 generated by the Erase-a-Base system. It encompasses nucleotides 1 to 1000 of M3/6 and can be released from the vector using the restriction enzymes EcoRI and XbaI.

Sequencing of M3/6.

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A nested set of deletion clones of the 2.5 kb cDNA was generated using the Erase-a-Base System commercially available from Promega. These clones were sequenced using double stranded sequencing protocol from USB. Sequencing reactions were resolved 5 on a standard 6% acrylamide gel and visualised by autoradiography after overnight exposure at room temperature. Sequence analysis was done using the GCG Wisconsin package version 8.

Sequence comparisons (see Figure 5) suggest that the M3/6 novel gene described is also a dual specificity phosphatase and will 10 be able to dephosphorylate MAP kinase. In addition, portions of the murine M3/6 gene show considerable homology to the human Hb5 gene homologue.

The human Hb5 gene was isolated by screening a Clontech (commercially available) human foetal brain cDNA library with the 15 M3/6 sequence.

EXAMPLE 2 - Protein distribution in tissues

RNA extraction and Northern blotting.

RNA was extracted from mouse tissue following the method of Chomczynski, P. and Sacchi, N. (1987, Anal. Biochem. 162, 156-20 159). poly A⁺ plus RNA was prepared from 100 μ g of total RNA using the Dynabeads mRNA purification kit from Dynal. Northern blots were prepared according to Current protocols in Molecular Biology. The human fetal tissue Northern was obtained from Clontech. Hybridisation was carried out at 42°C and the blots 25 were washed to a stringency of 0.1xSSC, 0.1%SDS at 55°C. The blots were visualised by autoradiography after exposure for one-two days at -70°C.

The results of the hybridisation of the M3/6 clone to Northern blot containing several mouse tissues were examined. A band at 30 5kb in mouse eye and brain was seen, but no bands of significance were seen in spleen, skeletal muscle, small intestine or liver. The filter was washed at 0.1 x SSC at 50°C. A 1.8kb band is seen in mouse lung with a faint band at 5kb. A similar band at 5kb

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is seen when a subclone of M3/6, designated M3/6/4e (nucleotides 1 to 1004) was used. In this case the 5kb band in lung is much stronger.

5 Hybridisation of M3/6/4e to a Northern blot of human fetal tissues again showed the 5kb transcript predominantly in the brain and to a lesser extent the lung, but not the kidney or liver to any significant extent. This blot is evidence of the sequence conservation of this gene between mouse and man.

EXAMPLE 3 - Assay

10 **In vitro transcription-translation assay.**

The pcDNAII vector utilises SP6 and T7 promoters which can be directly used for *in vitro* transcription-translation assays. One μ g of RNase free circular plasmid DNA containing the insert was used for each reaction. The assay was performed according to 15 the instructions provided with the Promega TNT Coupled Reticulocyte Lysate Systems. The synthesized proteins were analyzed by SDS gel electrophoresis on a 10% acrylamide gel and visualised by autoradiography after 1 hr exposure at room temperature. Luciferase-encoding plasmids were used as controls 20 for this assay.

An analysis of the M3/6 clone in the transcription/translation coupled reticulocyte assay indicated that the protein product was 80kD indicating that the translation of the mRNA must extend through and beyond the triplet repeats. The assay was carried 25 out using a kit from Promega according to the manufacturer's instructions.

EXAMPLE 4 - B8 Homology

Hybridisation of oligonucleotide M3/6-c.

M3/6-c is a 19-mer oligonucleotide the sequence of which is 30 CTTGGTCATCGACAGCCGG and is from the cdc25 homology region of M3/6. The oligonucleotide was radiolabelled using Promega

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polynucleotide kinase and γ dATP according to the manufacturer's instructions. Hybridisation was effected at 42°C and washes were done in 3xSSC, 0.1%SDS at room temperature for the cosmids and at 55°C for the cosmid subclones.

5 The subclone filters were washed at 3xSSC at 55°C. A strong signal was obtained. This suggests that a human sequence with high homology to this motif is present in B8. B8 contains markers (e.g.G1 and CMS1) which are in linkage disequilibrium with autosomal spinal muscular atrophy. Thus this PTP is a
10 candidate for this motor neuron disorder and parts of it may be useful diagnostically.

EXAMPLE 5 - M3/6 Expression

Proof that M3/6 encodes a cytoplasmic protein, which was expressed in PC12 cells, was derived from the following
15 experiment. A plasmid capable of directing expression of the M3/6 gene in a mammalian cell line was constructed by cloning the M3/6 cDNA into the polylinker of the vector pEFmycplLINK²⁹. This results in the expression of a fusion protein between the myc epitope (MEQKLISEEDL), recognised by the monoclonal antibody
20 9E10, and the protein of the invention under the control of the Elongation Factor gene promoter. This DNA construct was microinjected into PC12 cells. These cells are able to undergo neurite outgrowth typical of neuronal cells when stimulated with Nerve Growth Factor (NGF). Expression of M3/6 was monitored by
25 staining with the α -myc epitope antibody 9E10. This revealed the surprising and novel finding that M3/6 encodes a cytoplasmic protein. Where the localization of other potential MAP kinase phosphatases has been determined, this has been exclusively nuclear. Furthermore expression of M3/6 failed to block NGF-
30 stimulated neurite outgrowth which is surprising as expression of a MAP kinase phosphatase might be expected to block this MAP kinase dependent process.

Given the unusual cytoplasmic location of M3/6 it is possible that mutation or frameshift at the triplet repeat could lead to
35 a change in the subcellular location of the protein. This might

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lead to its relocation to the nucleus which may be a 'default' location for proteins of this family. Potentially this could lead to a loss or gain of function.

EXAMPLE 6 - Tests for MAP kinase phosphatase activity

- 5 The putative phosphatase was expressed and purified from bacterial or insect or mammalian cells followed by incubation with *in vitro* ^{32}P phosphorylated MAP kinase. Dephosphorylation of the MAP kinase can be assayed by gel electrophoresis followed by autoradiography.
- 10 An alternative assay involves co-expression of the putative phosphatase and a myc-epitope tagged version of MAP kinase in COS cells. Stimulation of these transfected cells with e.g. serum or EGF leads to a mobility shift in the MAP kinase which is revealed by gel electrophoresis, western blotting and probing
- 15 with a myc epitope recognising antibody. Co-expression of a MAP kinase phosphatase should lead to the abolition of this mobility shift.

This specification describes the identification of a novel gene encoding a novel protein that is highly likely to be a phosphatase which is a member of a sub-family of dual specificity threonine-tyrosine phosphatases expressed in neuronal tissue. It has a motif which shows very high homology to the yeast cdc25 yeast tyrosine phosphatases and possesses the characteristic conserved catalytic domain of all phosphatases. A transcription/translation coupling experiment (Example 3) has confirmed the presence of an expressible open reading frame and strongly suggests that the complex repeat is expressed as part of the 3' domain of the molecule. Since this may expand by replication slippage or other mechanisms as in other neurological disorders, any change in the size of this triplet repeat may give rise to molecular pathology.

The presence of the crosshybridisation of this sequence to human sequences derived from the candidate gene region for SMA makes this a candidate gene for the disorder. Since the gene is

expressed in brain and lung, but predominantly in brain, any change in the function of the gene might give rise to a neurological disorder. This can be tested by using the sequence or part of the sequence as a probe to hybridise to DNA from 5 patients with such diseases. Alterations in DNA from patients might also be seen using PCR primers derived from the corresponding human sequence. A change in the protein might also be detected using antibodies raised from peptides or expressed portions of this sequence and the investigation of muscle 10 biopsies.

EXAMPLE 7

Chromosomal Localization and Genomic Organization of Hb5.

HB5 cDNA was used previously for fluorescence *in situ* hybridisation (FISH) analysis on human metaphase chromosomes 15 (Theodosiou et al., 1996). It mapped to three locations with the principal peaks being on 10q11.2 and distal 11p15, with a further peak on 10q22. To further refine the chromosomal localisation of HB5 both a human chromosome 11 cosmid library (Smith et al., 1993) and a total human genomic PAC library (Ioannou et al., 20 1994) were screened with M3/6-4e and HB5 respectively. Four cosmids and nine PACs were isolated. All nine PACs gave an identical PstI restriction pattern when probed with HB5 that was entirely different from that of the cosmids, whose pattern was similarly identical. However both PACs and cosmids showed 25 cognate bands with PstI-digested total human genomic DNA. Thus cDNA-positive cosmid bands of approximately 2.3kb (doublet), 1.6kb (dimorphic with a 2.0kb band) and 1.05kb and PAC bands of 1kb and 3kb are seen in digests of total human DNA. The possibility of other copies of this gene or related genes is 30 suggested by other bands seen in the genomic DNA digests at approximately 1kb and 4kb. To assign a chromosomal localisation to these two separate genomic clone contigs one cosmid (cSRL 15a6) and two of the PACs (86N13 and 234B10) were used in FISH experiments. The cosmid maps uniquely to 11p15.5, whilst the 35 PACs both map to 10q11.2. No signal from either was seen corresponding to the minor peak identified by FISH with HB5 cDNA on 10q22 (Theodosiou et al., 1996).

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PCR analysis of the PAC clones using oligonucleotide primers based on the cDNA sequence showed that in all cases the size of the PCR amplification product was exactly the same size in both PACs and cDNA. This suggests that the PAC, and hence the 5 chromosome 10q11.2 copy of the gene is intronless and presumably a pseudogene. In contrast, the PCR products from the cosmid were, for the most part larger than the cDNA, suggesting the presence of introns. Subclones of the cosmid that were positive by hybridisation to the cDNA were sequenced to determine the 10 intron/exon boundaries and the flanking intronic sequences by comparison with the cDNA sequence. A graphical representation of the hVH-5 gene is shown in Fig. 6. The 1875bp open reading frame coding for hVH-5 is distributed over 6 exons, the smallest of which is 124bp (Table 1). The sizes of exon 1 and exon 5 have 15 not been determined since neither the transcription start site nor the polyadenylation signal for this gene have been found but, given a mRNA size of 5kb (Martell et al., 1995; Theodosiou et al., 1996) and assuming no 5' or 3' untranslated exons (as in CL100 (Kwak et al., 1994) the gene is spread over not more than 20 13kb.

The introns range in size from 193bp to approximately 4.75kb, with the second intron being by far the largest. The first exon contains the initiating methionine and the first CH2 (cdc25 homology 2) domain. The second CH2 domain is split between exons 25 2 and 3. Exon 5 contains the entire conserved catalytic PTPase domain, whilst the entire PEST (proline, glutamic acid, serine and threonine-rich) domain is contained within exon 6, which also contains the translation termination codon and all the 3' UTR so far described.

30 Using conserved primers flanking the trinucleotide repeat found in the mouse cDNA, M3/6 (Theodosiou et al., 1996) PCR analysis using the cosmids and PACs as templates showed that both the chromosome 10 and 11 copies of the human gene gave the size of product predicted from the human hVH-5 cDNA sequence. This was 35 confirmed in the chromosome 11 cosmid by sequencing using these same primers. In addition, no polymorphism for this repeat was noted among a small number of human individuals. Thus no

evidence was found for a copy of this gene containing the complex trinucleotide repeat found in mouse.

EXAMPLE 8 - Loss of Heterozygosity of hVH-5 in lung tumours

The region of chromosome 11q to which hVH-5 maps has been
5 implicated in the development of non-small cell lung cancer (NSCLC) breast cancer, rhabdomyosarcoma, Wilm's tumour, bladder cancer and testicular cancer (see Bepler and Garcia, 1994). Given the previously suggested potential tumour-suppressor activity of hVH-5 (Martell et al., 1995; Theodosiou et al., 1996)
10 we investigated loss of heterozygosity at this locus in 15 lung tumour samples. Eight of these were heterozygous for a PstI polymorphism in DNA from normal blood, one of which showed loss of heterozygosity in DNA from the corresponding tumour.

EXAMPLE 9 - Analysis of Methylation at the hVH-5 locus

15 A number of genes which map to human chromosome 11p15.5 are imprinted, that is only one of the parental alleles is expressed in somatic cells (Barlow, 1995). These include IGF2 and H19 (Rainier et al., 1993). One phenomenon associated with imprinting is the differential methylation of the parental
20 alleles (Barlow, 1995). It has recently been suggested that imprinted genes have few and small introns (Hurst et al., 1996). Since hVH-5 both maps to chromosome 11p15.5 and has few, small introns, there is the possibility that this gene might also be imprinted. Imprinting of the gene from normal adult brain and
25 lung is studied as is imprinting in fetal and tumour cells. Comparison of the patterns of imprinting may be used to provide diagnostic and/or prognostic assays of disease status. Diseases include proliferative diseases of lung and/or brain tissue.

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CLAIMS

1. A polypeptide comprising a murine phosphatase designated M3/6 or a human or other mammalian homologue thereof which phosphatase is characterized by the following features:
 - (a) it is encoded by a cDNA sequence obtainable from a mammalian brain cDNA library, said DNA sequence being selectively detectable with a murine DNA sequence as shown in Figure 1 or one or more of the human DNA sequences shown in Figure 3; and
 - (b) it comprises a phosphatase catalytic domain of the sequence VHCXAGXXRSX, where X is any amino acid.
2. A polypeptide comprising:
 - (a) an allelic variant of a protein as defined in claim 1;
 - (b) a protein at least 80% homologous to a protein as defined in claim 1;
 - (c) a fragment of a protein as defined in claim 1 or (a) or (b) above having phosphatase activity and being of at least 15 amino acids long; or
 - (d) a fusion protein comprising a protein as defined in claim 1 or any one of (a) to (c) above.
3. A polypeptide according to claim 1 or 2 carrying a revealing or detectable label.
4. A polypeptide according to claim 1, 2 or 3 fixed to a solid phase.
5. A polynucleotide which comprises:
 - (a) a sequence encoding a protein or polypeptide as defined in claim 1 or 2 or the complement of said sequence;
 - (b) a sequence of nucleotides shown in Figure 1 or Figure 2;
 - (c) a sequence capable of selectively hybridising to a sequence in either (a) or (b); or

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(d) a fragment of any of the sequences in (a) to (c).

6. A polynucleotide according to claim 5 which is a DNA polynucleotide.

7. A polynucleotide according to claim 5 or 6 which comprises at least 20 nucleotides.

8. A polynucleotide according to any of claims 5 to 7 which comprises the cDNA sequence shown in Figure 1.

9. A polynucleotide according to any of claims 5 to 8 carrying a revealing or detectable label.

10. A vector comprising a polynucleotide according to any of claims 5 to 9.

11. A vector according to claim 10 which is a recombinant replicable vector comprising a coding sequence which encodes a polypeptide as defined in claim 1 or 2.

12. A host cell comprising a vector according to claim 11.

13. A host cell according to claim 12 transformed by, or transfected with, a recombinant vector according to claim 11.

14. A host cell transformed by a recombinant vector according to claim 11 wherein the coding sequence is operably linked to a control sequence capable of providing for the expression of the coding sequence by the host cell.

15. A process for preparing a polypeptide as defined in claim 1 or 2, the process comprising cultivating a host cell according to any of claims 12 to 14 under conditions providing for expression of the recombinant vector of the coding sequence, and recovering the expressed polypeptide.

16. An antibody or a fragment thereof capable of binding to a polypeptide as defined in claim 1 or 2.

17. A screening assay for identifying a putative chemotherapeutic agent for the treatment of disease, the assay comprising:

(A) bringing into contact:

(i) a phosphorylated polypeptide which can be dephosphorylated by M3/6;

(ii) a polypeptide as defined in claim 1 or 2; and

(iii) a putative chemotherapeutic agent;

under conditions in which component (ii) would dephosphorylate component (i) in the absence of (iii); and

(B) measuring the extent to which component (iii) is able to disrupt, interfere with or inhibit dephosphorylation.

18. An assay according to claim 17 wherein the putative chemotherapeutic agent is a fragment of 10 or more amino acids of a polypeptide as defined in claim 2.

19. A method of diagnosing susceptibility to a disease or disorder, the method comprising detecting an amplification or mutation in a (GGC)_n, (GGT)_n, (AGT)_m or (AGC)_m repeat where n and m independently represent an integer from 2 to 20 in a region of the human genome corresponding to the location of a polynucleotide according to claim 5.

20. A method according to claim 19 wherein n is an integer from 15 to 20 and m is an integer from 4 to 20.

21. An isolated polypeptide which comprises the M3/6 sequence shown in Figure 2.

22. An isolated polynucleotide encoding the polypeptide of claim 21.

23. An isolated polynucleotide according to claim 22 which has the sequence depicted in Figure 2.

FIGURE 1

GGCAGGTCTGGCACCATGCACTAGGATACCCAGAACGCTGCAAGGCCACGCCCTCTCAC
TTCAGGGTCACTCTCCCCATTGCCACCAACCCACATGGCTGGGATCGCTCCCGAG
GAAGGTGATGGACGAAAGAACTGGCAGCCTGCTGGCTGGCGGGCTGGGGACCCCT
GGTCATCGACAGCCGGTCTCGTGGAGTATAACAGCTGCCACGTGCTGAGCTGTGAA
TATCTGCTGTTCAAAGCTGGTAAGCGGCCCTCAGCAGGAAAAGTGACAATTGCTGA
GCTTATCCAGCCTGCTACACGGAGCCAGGTGGATGCCACAGAACACAGGTGAGTGGT
GTATGACCAGAGCACACGAGATGCCAGCGTGGCAGCACAGCTTCTGTCCATCCT
GCTCAGCAAGCTGGACGGCTGTTGACAGTGTGGCATCCTCACAGGACGTTGCCACC
TTCTCCTCTGCTTCCCTGGCCTCTGTGAGGCAAGCTGCCACTTACCGTCCATGAGCC
TCTCTCAGCCCTGCCCTGTCAGCTGGCCTGACAGTGTGGCATCCTCACAGGACGTTGCCACC
ACCTGGGCTCTCAGAAAGATGTCTGAACAAGGATCTGATGACCCAAAACGGAATAAGCT
ATGTCCTCAATGCCAGCAACTCTGCCCTAAACCGGACTTCATCTGTGAGAGCCGTTCA
TGCATATCCCCATCAATGACAACACTCTGTGAAAAGCTGCTGCCCTGGCTGGACAAGTCCA
TCGAGTTTATTGATAAGCCAAGCTGTCCAGCTGCCAGTCATTGTTACTGTCTGGCTG
GCATCTCGCTCTGCCACCATGCCATCGCGTACATCATGAAAACCATGGCATGTCTT
CTGACGACGACATACAGGTTGTGAAGGATCGGCCCTCCATCTGCCCAACTTCAACT
TCCTGGGCCAGTTGCTGGAGTATGAGAGGAGTCTGAAGCTGCTGGCTGCCCTGCAGACTG
ATGGACCTCACTGGGACCCCTGAGCCCTCATGGGCCCGCAGCAGGACATCCACTGC
CCCGGCTGCCACCATCTACCTCAGAGAGCGCTGCCACTGGAGCGAGGAGCCACCGCAG
CCAGGGAGGGCAGCCCAAGTGCTGGAGG. ATGC. TCCGATCCCCAGCACAGCTCCAGC
CACCAGG. CGGCTGCAG. CAGG. CCTGC. GTGGCCTGCACCTCTCCCTGACCCCTC
CAGGACACCAACCGCCTCAAG. CGTTCTTTCCCTGGACATCAAGTGGCCTATGCACC
CAGCAGGAGGCCGACTTCCCGCCCNACCNAGCCCCGGTGAAGCCCCAAGCTCTNAA
GCTGACAGCCNGTCTGGGGNACACTGGCCTGCCCTGCCAGCCAGACAGCCGGAC
TCCGTTCCAGAGTGGCCACGACC. CGCG. CGACGCCCCCGGCTAGTTCGCCCTG
CCCGCTCCCCCGCATGGCTGGCCTGAACCTTGGAGACAGGCCCGCAGACTCCAC
GGCASSCTCTGCCCTGCGGCCGGCTGCCCTGGCCCTGCCAGCCGGCTGGNCCCG
GGGCTGGGTGCCGCCACTGGACTCCCCAGGCACACCGTCGCCNCCAGGNNGCAGGGTC
CAGGCAGCTGTGTTCTCCCTTGGCCGGTAAGTGAGCGNANCAGGCCGGTAACAG
CAGCAGCAGYGGTGGTGGTGGTGGTGGTGGYGGCGGCCGGCGGGCGGGCGGGCG
CAGCAGCAGCAGCAGCAACAGCAGCAGCAGCAGCAGCAGCAGCAGCAGCAGCAG
TAGTAGTAGTAGTAGTGACCTGCGGAGGCCGGATGTGCGGACCCGCTGGCCGAGGAGCC

TGCTGCAGATGCACAGTTCAAGAGGCGCAGCTGCCAGATGGAGTTGAAGAGGGCATGGT
GGAGGGGGCGGCACGTGCAGAGCTCTGGCAGNCCTGGCAAGCAAACCCAGCTCTGGCA
GCGTGGAGGTATCGAAGTATCGTGCCTTCAGAAGTCCCTGTGCCCTTGCTCCAGCCAGG
CCAGGTATAAATATATATATAAAACACACAGAAAAGGTAAATGGTTTAC..TGC
AATTTTATCAAGAAGTAAATATT.CGATTTT.ATTATTTAAGCTAGTGATCTGGCAA
CTGTGCGGGGCGGCCCTAAAGCTCTGTTTACTGTCGGTATTTAAACTGAAACAGGTT
TCTAAGCAATATGAGGCCACCTTCAATCCCAAATGGTTGACAGGCCCTGGGCCCTCCT
T.GCCCCCTCCCCCTGGAAACATTACTGACCTTCAAAGAGCTGCCAGCTTCTGCAC
TTTTACATAAGAAAAAAGGGGGGGGGRAA

FIGURE 2

FIGURE 3

SmaI subclone of HB5a/3 #2 sequenced with T3 17/7/95

SCORES Init1: 463 Initn: 527 Opt: 557
85.2% identity in 182 bp overlap

1049	1039	1029	1019	1009	999	990
M3-6.S AAGTGAGGTCCATCAGTCTGCAGGGCAGCCAGCTTCACTCTCTACACTCCAGC						
Hb5s2t			AGCAGCTTCAGGCTCGGCTCGTACTCCAGC			
			10	20	30	
989	979	969	959	949	939	930
M3-6.S AACTGGCCCAGGAAGTTGAAGTTGGGCAGATGGAGGGGCCGATCCTTCACAAACCTG						
Hb5s2t AGCTGGCCCAGGAAGTTGAAGTTGGGCAGATGGACNNNCCTGTCTTACCGAACCTG			|||||	|||||	|||||	|||||
			40	50	60	70
			80	90		
929	919	909	899	889	879	870
M3-6.S TATGCGTCGTCAAGAACATGCCATGGTTTATGATGTACGCGATGGCAATGGTGGCA						
Hb5s2t TAGGCNTCGTGGAGGACATGCCATGGTCTCATGATGTAGGCATGGCAGATGGTGGC-			|||||	|||||	|||||	|||||
			100	110	120	130
			140			
869	859	849	839	829	819	810
M3-6.S GAGCGAGAGATGCCAGCCAGACAGTGAACAATGACTTGGCAGCTGGACAGCTTGGCTTA						
Hb5s2t GAGCNGGAGATGCCAGCCAGACAGTGGACNAT			|||||	|||||	|||||	|||||
			150	160	170	180
809	799	789	779	769	759	750
M3-6.S TCAATAAAACTCGATGGACTTGTCCAGGCCAGGGCAGCAGCTTACAGTAGTTGTCATTG						

SCORES Init1: 343 Initn: 343 Opt: 387
78.8% identity in 156 bp overlap

1880	1890	1900	1910	1920	1930
M3-6.S CGGAGGCGGATGTGCGGACCGGCTGGCCGAGGAGCCTGCTGCAGATGCACAGTTCAAG					
Hb5s1t			GAGGAGCCGGCCCCGGAGACGCAGTCAAG		
			10	20	30
1940	1950	1960	1970	1980	1990
M3-6.S AGGCAGCTGCCAGATGGAGTTCGAAGAGGGCATGGTGGAGGGCGGCACGTGCAGAGC					
Hb5s1t CGCCGCAGCTGCCAGATGGAGTTCGAGGAGGGCATGGTGGAGGGC-GCNCNCNGCAGG					
40	50	60	70	80	
2000	2010	2020	2030	2040	2050
M3-6.S TCTGGCAGNCCT-GGCAAGCAAACAGCTCTCTGGCAGCGTGGAGGTATCGAAGTAT					
Hb5s1t AGCTGGCCGCCCTGGCAAGCTGGCGAGCTCTCGGGCTGGAGGTATCGAGGTGT					
90	100	110	120	130	140
2060	2070	2080	2090	2100	2110
M3-6.S CGTGCCTTCAGAAGTCCCTGTGCCCTGCTCCAGCCAGGCCAGGTATAAATATATATTAT					
Hb5s1t CCTGACCCCC					
150					

SCORES Init1: 241 Initn: 241 Opt: 323
 82.4% identity in 119 bp overlap

1359	1349	1339	1329	1319	1309
M3-6.S	CNGGTNGGCCGGAAAGTCGGGCCTCCTGCTGGGTGCATAGGCCGACTTGATGTCCAGG				
Hb5s3t			CTAGGGGCATGGCAGACTTGATGTCCAGG		
			10	20	30
1299	1289	1279	1269	1259	1249
M3-6.S	AAAAAGGAACGCTTGAGGGGTTGGTGCCTGGAGGCCGTCAGAGGAGAGGTGCAGGCCA				
Hb5s3t	GAGAAGGAGGCC	GAGGGGTTAGTGCCTGCAGGCCG	CCGAGGAGAGGTGCAGGCCG		
40	50	60	70	80	90
1239	1229	1219	1209	1199	1189
M3-6.S	CGCAGGCCCTGCTGCAGCCGCCTGGGGCTGGAGCTGTGCTGGGATCGGAGCATCCCTC				
Hb5s3t	CGCA-GCCTNCTGCAG-TNCNCTGGTCNC				
100	110				

PstI subclone of HB5a/3 #2 sequenced with T7 primer 17/7/95

SCORES Init1: 213 Initn: 213 Opt: 227
 79.5% identity in 78 bp overlap

1029	1019	1009	999	989	979
M3-6.S	CTGCAGGGCAGCCAGCAGCTTCAGACTCCTCTCATACTCCAGCAACTGGCCAGGAAGTT				
Hb5p2t			CTCGTACCTCCAGCAGCTGGCCAGGAAGTT		
			10	20	30
969	959	949	939	929	919
M3-6.S	GAAGTTGGGAGATGGAGGGCGCCGATCTTCACAAACCTGTATCGTCGTCAAAGA				
Hb5p2t	GAAGTNNNNAGATGGACNNNCGCTGTCTTACGAACCTGTAGGC				
40	50	60	70		
909	899	889	879	869	859
M3-6.S	CATGCCCATGGTTTATGATGTACGCATGGCAATGGTGGCAGAGCAGAGATGCCAGC				

SCORES Init1: 169 Initn: 169 Opt: 202
 81.3% identity in 75 bp overlap

1330	1340	1350	1360	1370	1380
M3-6.S	TTTCCCGGCCCNACCNGACCCCCGGTGAAGCCCCAAGCTCT-NAAGCT-GACAGCCNGTC				
Hb5s4t			CCCCGAAGCTCTGCAAGCTGGACAGCCCCGTC		
			10	20	30

	1390	1400	1410	1420	1430	1440
M3-6.S	TGGGGGNACACTGGGCCTGCCCTGCCAGCCCAGACAGCCGGACTCCGTTCCAGAGTG					
	: ; : ;					
Hb5s4t	GGGGGCCGCNCTGGNCCGTNCTGCCAGCCGGACAGCCGGA					
	40	50	60	70		
	1450	1460	1470	1480	1490	1500
M3-6.S	CGGCCACGACCCCGCCGACGCCCGGCTAGTCGCCTGCCGCTCCCCGCGCA					

PstI subclone of HB5a/3 #2 sequenced with T3 primer 17/7/95

SCORES Init1: 151 Initn: 151 Opt: 241
76.0% identity in 104 bp overlap

	260	270	280	290	300	310
M3-6.S	CTGGTGAAGCGGCCTTCAGCAGGAAAAGTGACAATTGCTGAGCTTATCCAGCCTGCT					
	: ; : ;					
Hb5p2t	TTCCGGGGTGGCCATTGGGNNNNCATCCAGCCGGCT					
	10	20	30			
	320	330	340	350	360	370
M3-6.S	ACACGGAGCCAGGTGGATGCCACAGAACCCACAGGATGTAGTGGTGTATGACCAGAGCACA					
	: ; : ;					
Hb5p2t	GCACGCAG-CAGGTGGAGGCTACGGAGCCACAGGACGTGGTGGCTATGACCAGAGCAG					
	40	50	60	70	80	90
	380	390	400	410	420	430
M3-6.S	CGAGATGCCAGCGTGGCAGACAGCTTCCATCCTGCTCAGCAAGCTGGAC					
	: ;					
Hb5p2t	CGGGA-CNCAGCNT					
	100					

SmaI subclone of HB5a/3 #2 sequenced with T7 17/7/95

SCORES Init1: 151 Initn: 151 Opt: 236
77.9% identity in 95 bp overlap

	260	270	280	290	300	310
M3-6.S	CTGGTGAAGCGGCCTTCAGCAGGAAAAGTGACAATTGCTGAGCTTATCCAGCCTGCT					
	: ; : ;					
Hb5s2t	GGGTGGCCATTGGGNNNNCATCCAGCCGGCT					
	10	20	30			
	320	330	340	350	360	370
M3-6.S	ACACGGAGCCAGGTGGATGCCACAGAACCCACAGGATGTAGTGGTGTATGACCAGAGCACA					
	: ; : ;					
Hb5s2t	GCACGCAG-CAGGTGGAGGCTACGGAGCCACAGGACGTGGTGGCTATGACCAGAGCAG					
	40	50	60	70	80	90
	380	390	400	410	420	430
M3-6.S	CGAGATGCCAGCGTGGCAGACAGCTTCCATCCTGCTCAGCAAGCTGGAC					
	: ;					
Hb5s2t	CGGGA					

SCORES Initl: 133 Initn: 133 Opt: 224
69.8% identity in 116 bp overlap

1240	1250	1260	1270	1280	1290
M3-6.S CCTCTGACCGCTCCAGGACACCAACCGCTCAAGCGTTCTTTCCCTGGACATCAAGT					
Hb5p1t			TCAAGCG-TCTTCTCCCTGGACATCAAGT		
			19	20	

1300	1310	1320	1330	1340	1350
M3-6.S	CGGCCTATGCACCCAGCAGGAGGCCGACTTCCGGCCNACCGACCCCCGGTGAAGC				
Hb5plt	CTGCCATACNCCTCTAGCAGGGNGCCGANNNNNCCNNNC			CCCAGCCNNNCAGGGC	
39	49	59	69	79	89

1360	1370	1380	1390	1400	1410
M3-6.S CCCAAGCTCT-NAAGCT-GACAGCCNGTGGGGNACACTGGGCCTGCCCTGCCAG					
Hb5p1t CCCAAGCTCTCGNAAGCTGGACANNCGTGC					
89	100	110			

SCORES Initl: 129 Initn: 129 Opt: 213
72.0% identity in 100 bp overlap

M3-6.S 1000 1010 1020 1030 1040 1050
 CTGAAGCTGCTGGCTGCCCTGCAGACTGATGGACCTCACTGGGGACCCCTGAGCCCCCTC
 Hb5p3t GACCCGGGCACCCCCCTCAGGGACNCNGGAGCCTCG
 10 20 30

1060	1070	1080	1090	1100	1110		
M3-6.S	ATGGGCCCGCAGCAGGCATCCCCTGCCCCGGCTGCCACCATCTACCTCAGAGAGCGCT	|||||	|||||	|||||	|||||		
Hb5p3t	CCCAAGTCTGCGCGGGGCCCCGCTGCCACGGCTGCCACCACTACCTCAGAGAGCNCCT	49	50	60	70	80	90

M3-6.S 1120 1130 1140 1150 1160 1170
 GCCACTGGGAGCGAGGCAGCCACCGCAGCCAGGGAGGGCAGGCCAAGTGTGGAGGGATG
 Hb5p3t 1120 1130 1140 1150 1160 1170
 ||||| |||||
 GCCACAGGGATNCNNCTNCAGGGAGG
 100 110 120

```

SCORES      Init1: 112 Initn: 112 Opt: 184
            83.1% identity in 65 bp overlap

M3-6.S 1609      1599      1589      1579      1569      1559
GCCGGCTGGCAGGGCCAGGCAGGCCGGCGCGACAGGGCGAGA-GSSTGCCGTGGAGT

Hb5s4t          :|||||: :|||||: :|||||: :|||||: :|||||:
CCGACAGGGCCGAGACCGGTGCCGGAGT
                           10      20      30

M3-6.S 1549      1539      1529      1519      1509      1499
CTGCCGGGCCGTGTCTCAAAGTTCAAGGCCAGACCATGCGCGGGGGAGCGGGCAGGCAG

Hb5s4t          :|||||: :|||||: :|||||: :|||||: :|||||:
CTGCCGGGCCGATCGCCGAAGTTCAGGCCGAGGCTGT
                           40      50      60

M3-6.S 1489      1479      1469      1459      1449      1439
ACTAGCCGGGGGGCGTCGCCGCGGGCTCGGGCGGACTCTGGAACGGAGTCGGGGCT

```

SCORES Init1: 67 Initn: 67 Opt: 91
 58.6% identity in 87 bp overlap

	1310	1320	1330	1340	1350	
M3-6.S	GCCTATGCACCCAGCAGGAGGCCGACTTCCCGGCCCNACNGACCCCGG	---	TGAAG			
Hb5s5t	CCAAACAGCACCCCGCCCGCCCGCTGTGCGCCCTCGGGGCTGAAG					
	10	20	30	40		
	1360	1370	1380	1390	1400	1410
M3-6.S	CCCCAAGCTCTNAAGCTGACAGCCNGTCTGGGG	-GNACACTGGGCCTGCCCTGCCAGC				
Hb5s5t	CACCAAGGGCCCGTCGGGACGGCGTGCCTGGGGAGTCGAGCGGGGGT	GCCCAGGCCCCAT				
	50	60	70	80	90	100
	1420	1430	1440	1450	1460	1470
M3-6.S	CCAGACAGCCGGACTCCGTTCCAGAGTGC	GGCCACAGAACCCGCCGAGCAGCCCCCG				
Hb5s5t	C					

SmaI subclone of HB5a/3 #2 sequenced with T3 17/7/95

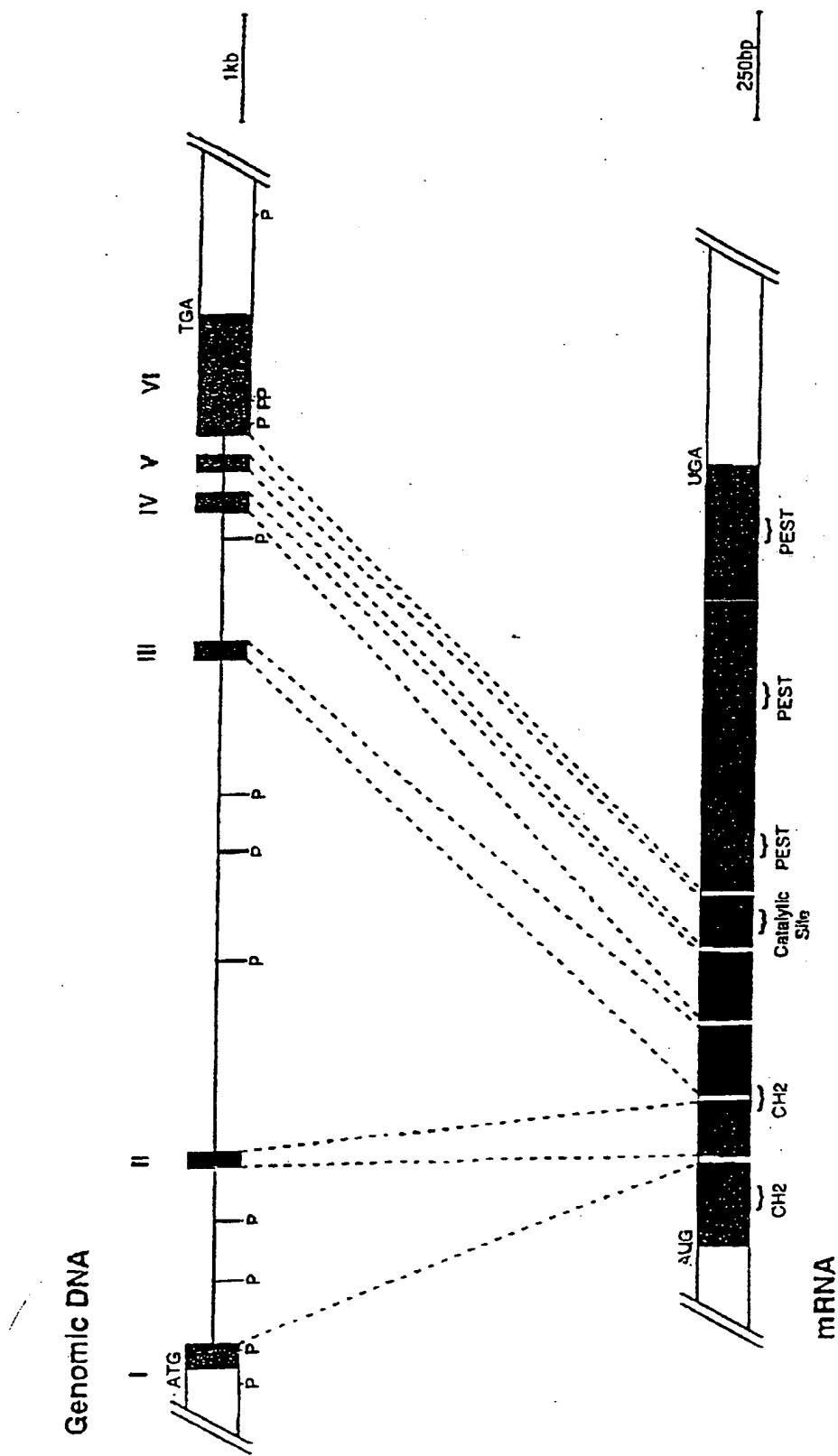
SCORES Init1: 44 Initn: 44 Opt: 62
 53.5% identity in 114 bp overlap

	250	260	270	280	290	300
M3-6.S	TTCAAAGCTGGTGAAGCGGGCGCTTCAGCAGGGAAAGTGACAAT	-TGCTGAGCTTATCC				
Hb5s2t	TCCAGCAGCTGGCCCAGGAAGTTGAAGTTGGCNAGATGGACNNNCNCTGTCC	TTACG				
	30	40	50	60	70	80
	310	320	330	340	350	360
M3-6.S	AGCCTGCTACAGGAGCCAGGTGG	--ATGCCACAGAACACAGGATGTAGTGGTGTATGA				
Hb5s2t	AACCTG-TAGGCNTCGTC	GGAGGACATGCCATGGCTTCATGATGTAGGCATNGCGA				
	90	100	110	120	130	140
	370	380	390	400	410	420
M3-6.S	--CCAGAGCACAGAGATGCCAGCGTGC	GGCAGCAGACAGCTCCTGTCCATCCTGCTC				
Hb5s2t	TGGTGGCGAGCNGGAGATGCCAGCAGACAGTGGACNAT					
	150	160	170	180		

FIGURE 5

M36	MAGDRLPRKV	MDAKRASILL	RGGPGCHLVI	DERSVEYNS	CHULSVNIC	50
CL100	MV---MEVGT	LDAGGQALL	GERAAQCLL	DRSEFARRA	CHIACSVNVR	47
Consensus	.....	DN	U	U	U	SVN
M36	CSKLMVRLQ	QGKVTLIAELI	QPATRSQVDA	TEPQD	WYD	100
CL100	FSTTIVRRAK	GAMGLEHIVP	NAELRGRLLAS	GAYHAW	WLLID	97
Consensus	S	M	R	W	D	100
M36	ADSHISILLS	R	DGCFDSD	W	EGK	145
CL100	HGCTHLAAG	W	ACCREARAAQ	Y	EGK	147
Consensus	.....	U	U	U	U	150
M36	SKSISCP	-----	-----	-----	SKRMLNK	179
CL100	PLHISIPSA	-----	ESGCSSG	-----	PLHISIPSA	196
Consensus	.....	U	U	U	U	200
M36	HTMTONGISY	VIA	NSNSCK	PDTCESRFM	HIPINDNCE	229
CL100	-----	-----	-----	-----	KLLPFLDKST	241
Consensus	-----	U	U	U	U	250
M36	EFIDKAK	SS	COMVIG	AGSISRSATTA	IAVYVIMKTHGMSS	279
CL100	DEODSIRNAG	GRVEVIG	-----	AGSISRSATTA	IAVYVIMKTRVKL	291
Consensus	.....	U	U	U	U	300
M36	RSISIPNF	F	COLLEVERS	-----	-----	
CL100	RSISIPNF	F	MGOLLOFESQ	-----	-----	
Consensus	RS	ISIPNF	F	COLL	U	

FIGURE 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB 96/01906

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C12N9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C07K C12N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JOURNAL OF NEUROCHEMISTRY, vol. 65, no. 4, 1995, PHILADELPHIA,US, pages 1823-1833, XP000196676 K.J. MARTELL ET AL.: "hVH-5: a protein-tyrosine phosphatase abundant in brain that inactivates mitogen-activated protein kinase" cited in the application see the whole document	1-4
A	---	5-23

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Date of the actual completion of the international search

14 January 1997

Date of mailing of the international search report

29.01.97

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Authorized officer

Mateo Rosell, A.M.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01906

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A	WO,A,94 01119 (NATIONAL UNIVERSITY OF SINGAPORE) 20 January 1994 see page 2, line 8-15 see page 8, line 13-15 ---	16
		-/-

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01906

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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P,X	JOURNAL OF BIOLOGICAL CHEMISTRY, vol. 271, no. 8, 1996, MARYLAND, US, pages 4319-4326, XP000611987 M. MUDA ET AL.: "MKP-3 a novel cytosolic protein-tyrosine phosphatase that exemplifies a new class of mitogen activated kinase phosphatase" see the whole document	1
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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB 96/01906

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